

Assessment of the Water Quality of Lake Sidi Boughaba (Ramsar Site 1980) Kenitra, Morocco.

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ABSTRACT: Sidi Boughaba Lake, part of a wetland complex of Morocco (Ramsar site in 1980) is located on the Atlantic coast of northwestern Morocco, oriented NNE - SSW and located in an interdunal depression. The existence of this body of water is due to the fact that the topographic surface is at a lower cost than that of the piezometric surface of the coastal water table, rainwater and runoff water. The objective of this study is to determine the physical and chemical characteristics of the waters of this lake. Thus, several water samples were taken monthly in the period 2016-2017. Parameters such as: temperature, pH, electrical conductivity (EC), chloride (Cl^-), turbidity (NTU), calcium (Ca^{2+}) and magnesium (Mg^{2+}). The results obtained show that the distribution of the analyzed elements in Lake waters is quite variable between seasons, as well as between stations. However, the analysis showed that the studied waters are very mineralized, with an EC between 7 g/l and 14.8 g/l. This mineralization is essentially evaporitic and is controlled by various processes, such as evaporation and marine influence by aerosol.

KEYWORDS: Assessment, characteristics, Physical Chemistry, Lake, Morocco

I. INTRODUCTION

Water is a vital part of life and is important for countless human activities. Water may be scarce in some places, such as arid and semi-arid areas, or simply of poor quality in other places. The degradation of water resources and aquatic ecosystems is a global and complex problem. The problem arises under the two aspects, quantitative and qualitative, often interdependent in arid and semi-arid zones (Rent, 1991). La dégradation des ressources en eau et des écosystèmes aquatiques est une problématique globale et complexe. Le problème se pose sous les deux aspects, quantitatifs et qualitatifs, souvent interdépendants en zones arides et semi-arides. The types of pollution that may reduce its ecological potential and have adverse effects on human health increasingly threaten aquatic ecosystems, especially lake ecosystems or wetlands, sites of our study. Moreover, the choice to study the waters of the Lake is motivated by their important roles in low water support, groundwater recharge, flood control, a filter for the purification of water and sources of biodiversity.

Study Area: Sidi Boughaba Lake is located on the Atlantic coast of northwestern Morocco, oriented NNE - SSW (Fig. 1) and located in an interdunal depression. It stretches for 5.5 km in length and varies in width from 100 to 350 meters and a depth of between 0.5 and 2.5 meters.

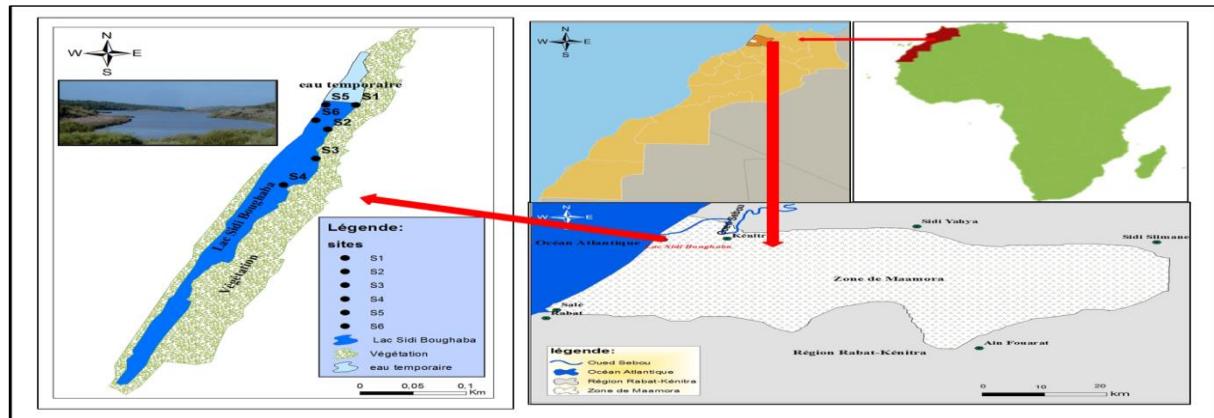


Figure 1: Geographical location of the study area

The existence of this body of water is due to the fact that the topographic surface is at a lower cost than that of the piezometric surface of the coastal water table, rainwater and runoff [1]. The maximum water level is at the end of winter (March) and minimum just before the return of rains (September). Due to the significant variation of the level (almost 1 m), only a portion of this lake, whose depth is sufficient, remains in water all year (well less than half of the surface)[2]

II. RESULTS AND DISCUSSIONS

The Temperature; Temperature is a fundamental physical factor in superficial and terrestrial aquatic environments. It greatly conditions the distribution of plant and animal organisms and influences the physical activity of living beings. It also controls the evolution and transformation in the aquatic environment of many chemical factors, including dissolved oxygen, a factor essential for aquatic organisms.

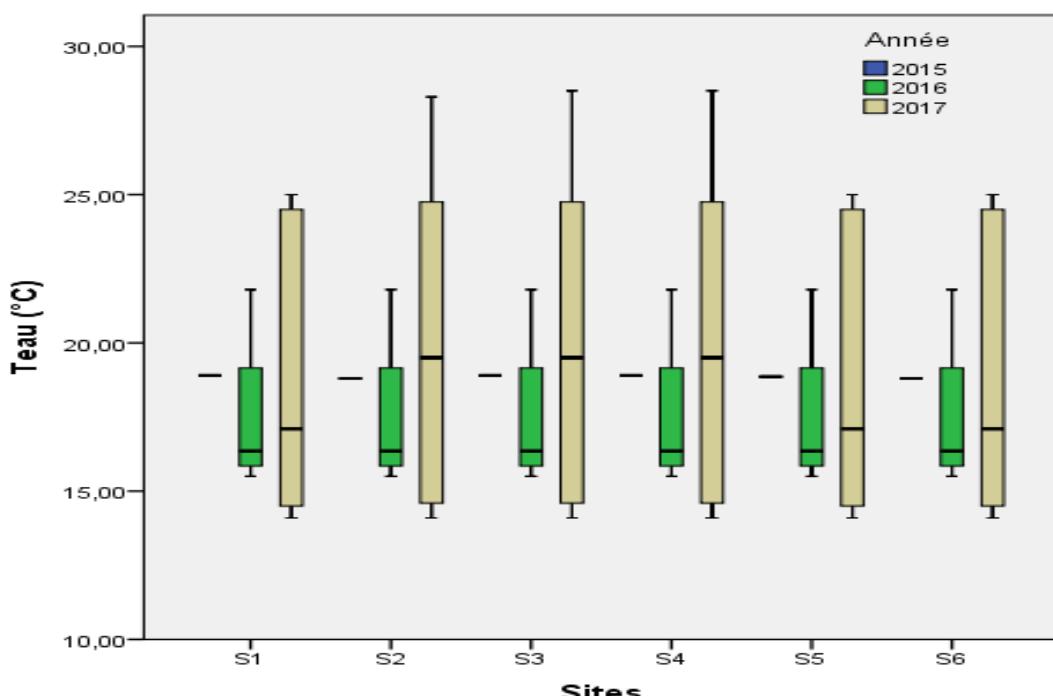


Figure 1: Box mustache graphical representation of water temperature data for Lac Sidi Boughaba during the study period (2015-2018)

The lake water temperature measured in situ varies between a minimum of 14.10°C and a maximum of 28.5°C , with an average of 18.72°C , a median of 17.36 and a variance coefficient of 18.27°C . The standard deviation is small (4.27), reflecting the low temperature variation of Lake water the representation of the temperature data in the form of box to mustache, traces a seasonal evolution with a clear sinusoidal pace. The waters of the Lake are very hot in the summer season showing maxima recorded during the month of October. They cool gradually in winter to reach the lowest temperatures (January). The temperature of the water evolves parallel to that of the air; this reflects well the influence of the climate of the region.

The spatial evolution of the temperature shows a constant horizontal gradient from S1 to S6, which translates into the homogeneity of the lake waters. Similar results have been highlighted in interior works (HRACH RAS 2010). The increase in temperature favors self-purification and increases the rate of sedimentation, which may be of interest in wastewater treatment plants. It can promote the mortality of certain species and the development of other

The turbidity: It characterizes the clarity of a water or its opalescence by the Tyndall effect (Dupont, 1981). It expresses the amount of suspended solids (microorganisms, algae, organic macromolecules) that are at the origin of the water disturbance (Beaux, 1997). In calm waters such as rivers or lakes that move slowly, turbidity is due to colloidal or fine dispersions. In rivers where the movements of liquids are rapid, the particles are of relatively large size. The majority of suspended solids are inorganic in nature, but sometimes organic substances are the principal constituents. (Jan and Gerald, 1993).

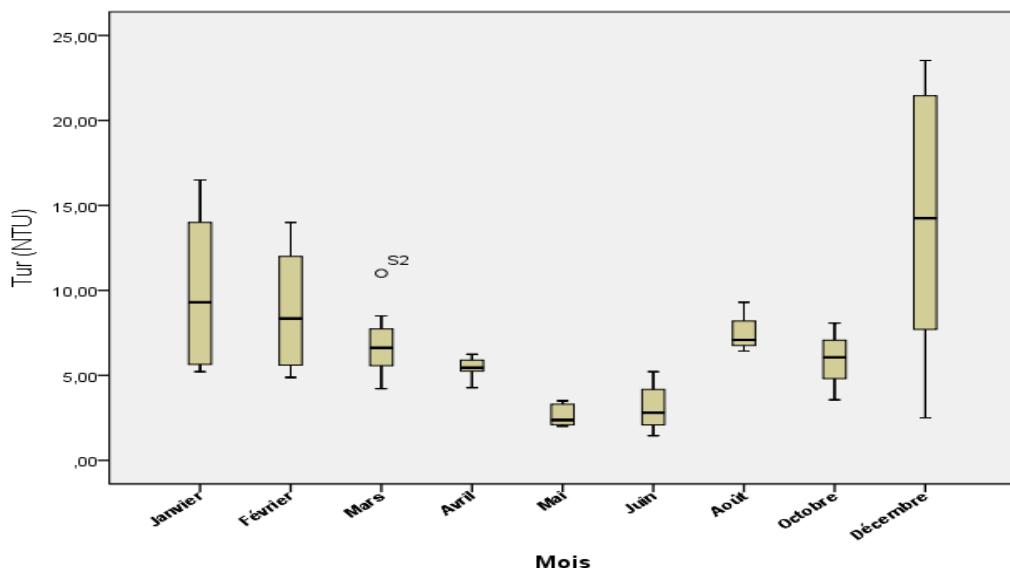


Figure 2: Mustache graphical representation of water turbidity data studied as a function of time

From Figures (3 and 4), the mean turbidity (7.68 ± 5.14 NTU) is greater than the median turbidity (5.98 NTU) with high variance (26.5). Turbidity is characterized by high values. It has significant variations and oscillates between a minimum of 1.45 NTU and a maximum of 23.53 NTU. The minimum value was recorded during the dry season (June), while the maximum value was observed during the period of rising water (December). What allows us to conclude, the increase of the temperature favors the sedimentation of the suspended particles in the water, by decreasing the turbidity, and, to justify it by several researchers.

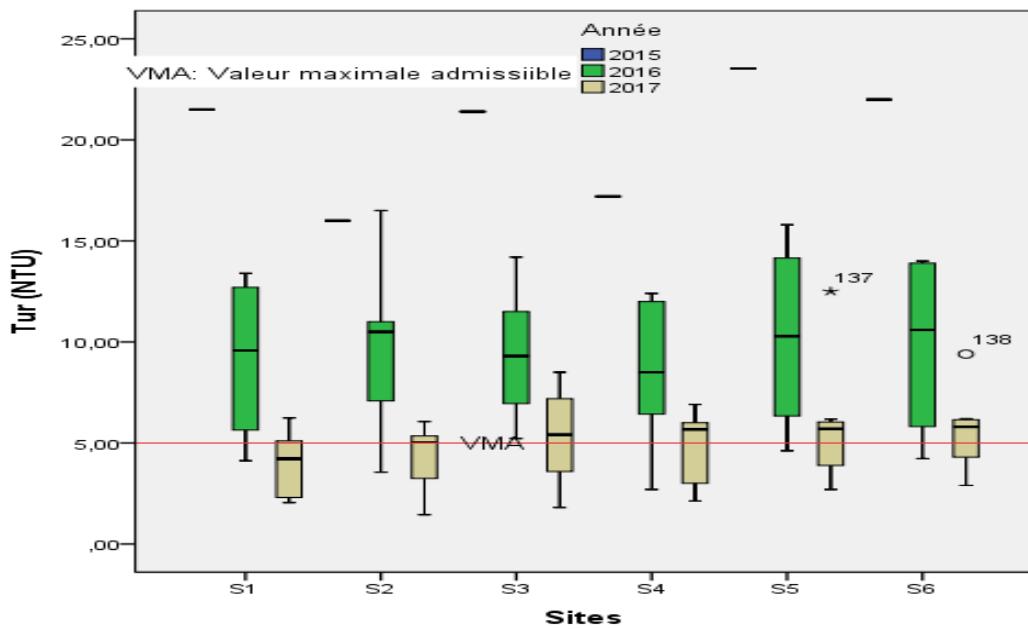


Figure 3: Box-mustache graphical representation of spatial data of turbidity in Lacustrine waters

The spatial-annual evolution shows us that the year 2016 is characterized by a very turbid water than that of the year 2017. The maximum admissible value is fixed at five NTU according to the Moroccan standards of potability. We find that the average values of the waters analyzed during our study (2016-2017) have turbidity levels higher than the maximum allowable value.

PH : The hydrogen potential depends on several factors such as dissolved oxygen, carbon dioxide and the rate of organic matter. Thus, a drop in pH marks the increase in the CO₂ content, the decrease in the O₂ content and the increase in the organic matter content.

Thugs, the altération of the minerals leads to a consumption of CO₂ and therefore induces an increase of the pH. It is also influenced by acid precipitation, biological activity and some industrial discharges. The values of the quality criterion for raw water supply are between 6.5 and 8.5 and between 6.5 and 9.0 for the protection of aquatic life[3]

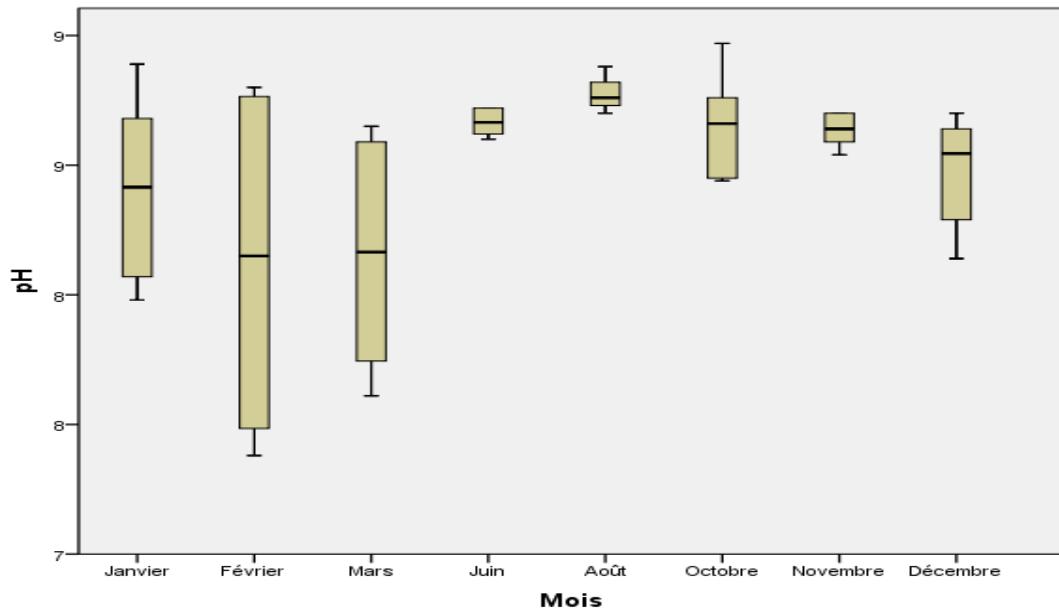


Figure 4: Temporal variation of the pH of the waters of Lake Sidi Boughaba during the study period for the six stations

The measurement of pH will have two applications to consider separately: the monitoring of water quality, on the one hand, and the thermodynamic studies of chemical equilibria, on the other hand. The major distinction lies in the level of accuracy and precision required for these two applications [4]. The box-and-whisker plot in Figure 5 illustrates the pH change for the eight campaigns.

The pH values in the study area range from a low of 7.38 to a high of 8.98. The mean is (8.41 ± 0.41) which is above the median (8.60). These values are therefore not different and reflect waters close to neutrality but slightly alkaline. This could result from a balance between high levels of carbon dioxide and dissolved calcium or magnesium bicarbonates, stabilized by the buffering effect of the high mineralization of water.

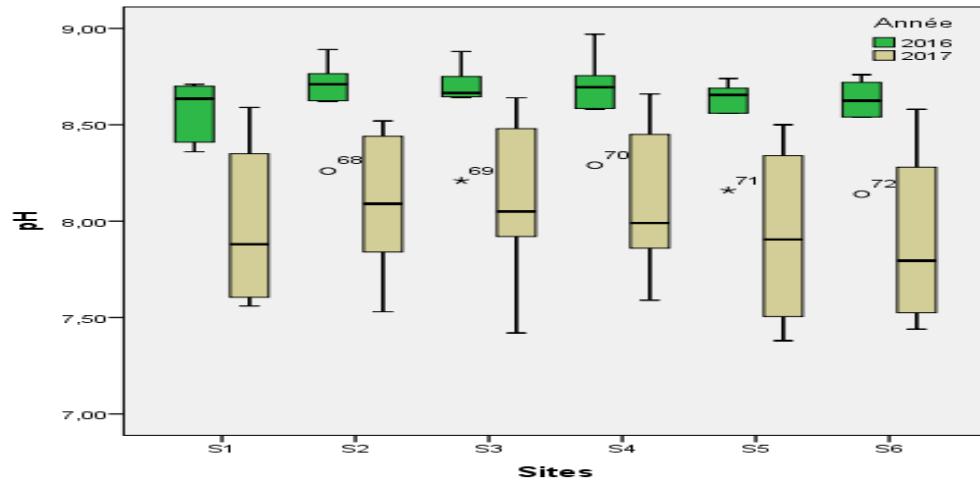


Figure 5: Représentation graphique en boîte à moustache des données du pH des eaux étudiées

The spatial evolution (Fig. 6) shows that there is very little variation in pH passing from one site to another. At the annual level, there is a difference in the same site; however, the year (2016) was characterized by pH values

well above those of the year (2017). This result could be explained by the fact that these are the areas in which photosynthetic activity of phytoplankton is highest.

Electrical conductivity : Electrical conductivity (EC) plays a very important role in the knowledge of the overall mineralization of water. It is proportional to the concentration of ionizable salts, which itself depends partly on the temperature of the water.

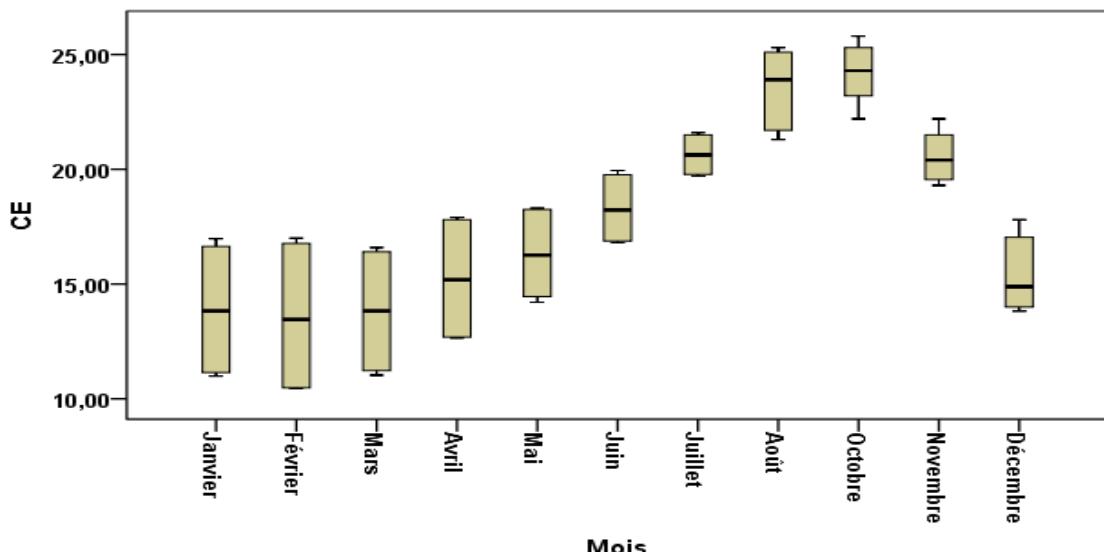


Figure 7: Temporal variation of the electrical conductivity of Lake Sidi Boughaba waters during the study period for the six stations

The electrical conductivity varies between 10.44 and 25.80 mS/cm, with an average of 17.22 mS/cm, 50% of the samples have values between 14.19 and 19.18 mS/cm, the average is greater than the median, which is in the order of 16.94; indicating a trend towards high values of electrical conductivity.

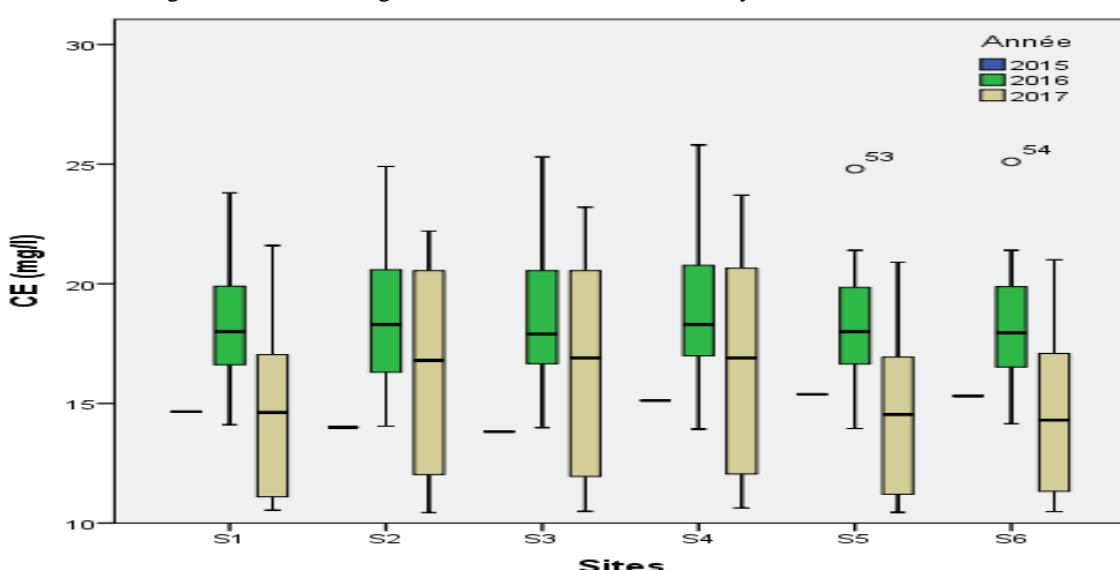


Figure 8: Amplitude of temporal variability of water EC for the six study stations

Examination of the two figures (7 and 8) showing the spatio-temporal evolution of the electrical conductivity of the waters of Lake Sidi Boughaba, show that the maximum value was recorded during the period of low water (October), against the Minimum value was recorded during the high-water period (February) which can be explained by a phenomenon of water dilution by increasing its volume during the rainy season. Electrical conductivity exhibits significant seasonal variability expressed by a high coefficient of variation 15.78 (Table). In addition, the electrical conductivity varies or a little passing from one site to another.

All the atypical values recorded in the mustache plot (Figure 8) are characterized by values above average electrical conductivity in both S5 and S6. This result is explained by the influence of the spread of the extreme values (Minimum and Maximum) compared to the central values (Average and Median). The waters of Lake Sidi Boughaba analyzed have generally very high conductivity values, far exceeding the guideline value set by the European standards (1.5 mS.cm^{-1}) and WHO.

Chloride : Chlorides are important inorganic anions contained in varying concentrations in natural waters, usually in the form of sodium (NaCl) and potassium (KCl) salts. They are often used as a pollution index. They influence aquatic fauna and flora as well as plant growth. Chlorides exist in almost all waters at variable contents [5]. They are not adsorbed by geological formations, do not combine easily with chemical elements and remain very mobile [6]. The concentration of chlorides shows a large variation, with a minimum of 3790.64 mg/l and a maximum of 11390 mg/l , the average is 6432.58 mg/l higher than the median of 5960.85 mg/l , which reflects a strong influence of high values.

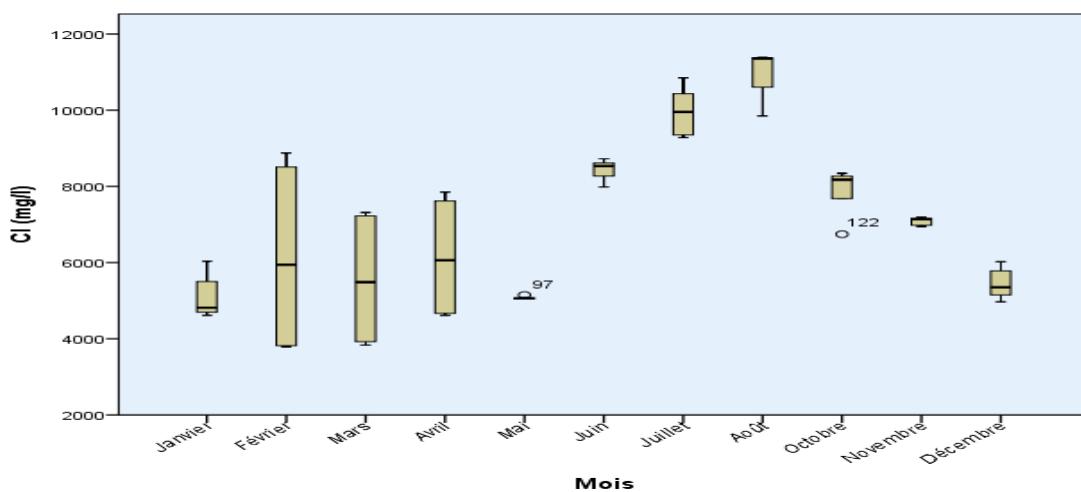


Figure 9: Box mustache graphic representation of water chloride data from Lake Sidi Boughaba during the study period

An examination of Figure 9 shows that the minimum value was recorded during the winter period during the month of February, while the maximum value was recorded during the dry season (August). The temporal evolution is marked by a strong lowering resulting from the dilution by the heavy precipitations and an increase in summer. This increase is due to the intensive evaporation of Lake water. And this, concord with what has underlined by MARGAT (1962), the chlorite of the waters could well be related to the nature of the salt lands crossed. But the evaporation, the aridity of the climate and the human activity accentuate the degree of salinity of the waters. In addition, the variability of chlorides does not show significant fluctuation from S1 to S6 figure 10.

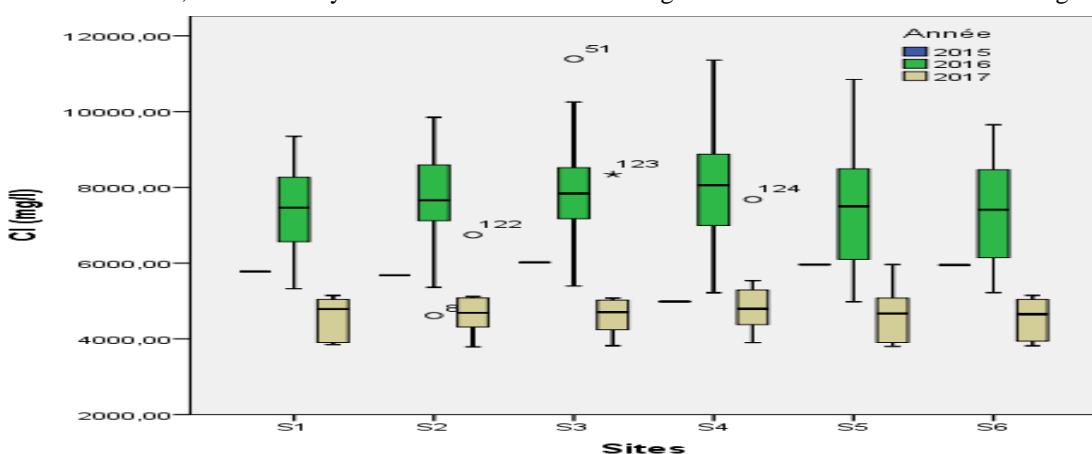


Figure 10: Amplitude of the temporal variability of the chlorides of the waters of Lake Sidi Boughaba for the six stations

Generally, chlorides are used to disinfect water, according to Moroccan standards of water intended for the production of drinking water, which require a maximum of 300 mg. L-1 and 750 mg. L-1 (mandatory value). For concentrations above this value, chloride gives a bad taste to water and drinks made from water. The presence of this ion in natural waters is due either to the leaching of sedimentary rocks and soils, or to the disinfection of domestic waters and industrial processes that use chlorine as a bleaching agent, household cleaning agents, and salt on the roads in winter.

Calcium (Ca^{2+}): The concentration of Ca^{2+} is directly related to the geological nature of the lands crossed by the water. Calcium ions result from the attack by carbon dioxide-laden water from limestone rocks or the simple dissolution of sulphates such as gypsum. Calcium plays an essential role in the constitution of skeletons and shells, and in cell permeability phenomena, it is concentrated by organisms from water or food. It can not in any case cause problems of drinkability, the only domestic drawback related to a high hardness is scaling. On the other hand, very soft water can lead to corrosion problems in the pipes [7] The waters of Lac Sidi Boughaba show calcium values ranging from 75 mg / l to 208.4 mg / l with an average value of around $(127.7 \pm 30.7 \text{ mg / l})$. Which explains why there are big differences between the different samples.

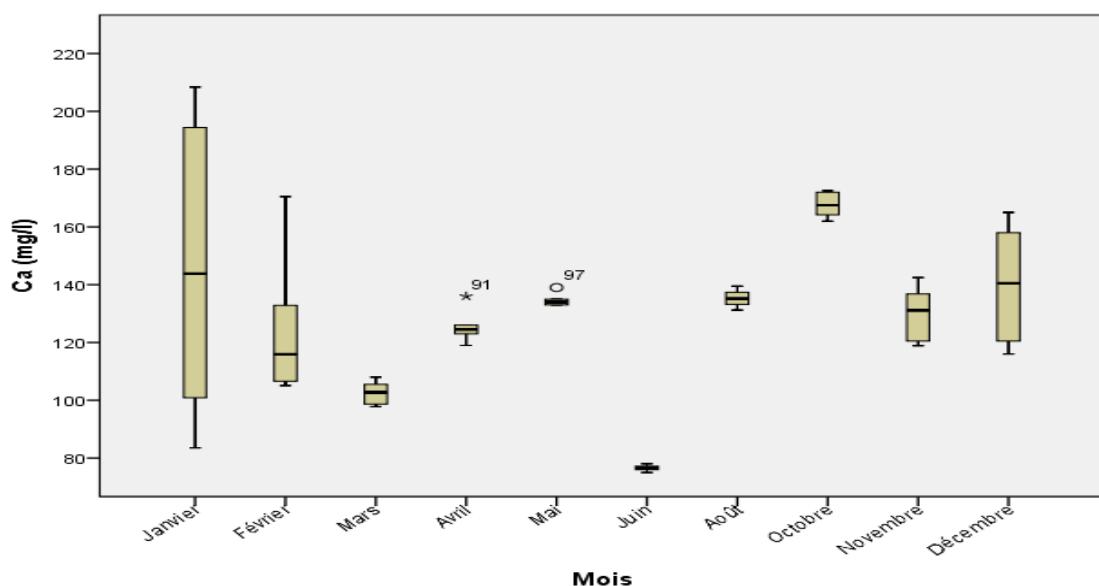


Figure 11: Box-mustache graphical representation of calcium data from Lake water during the study period

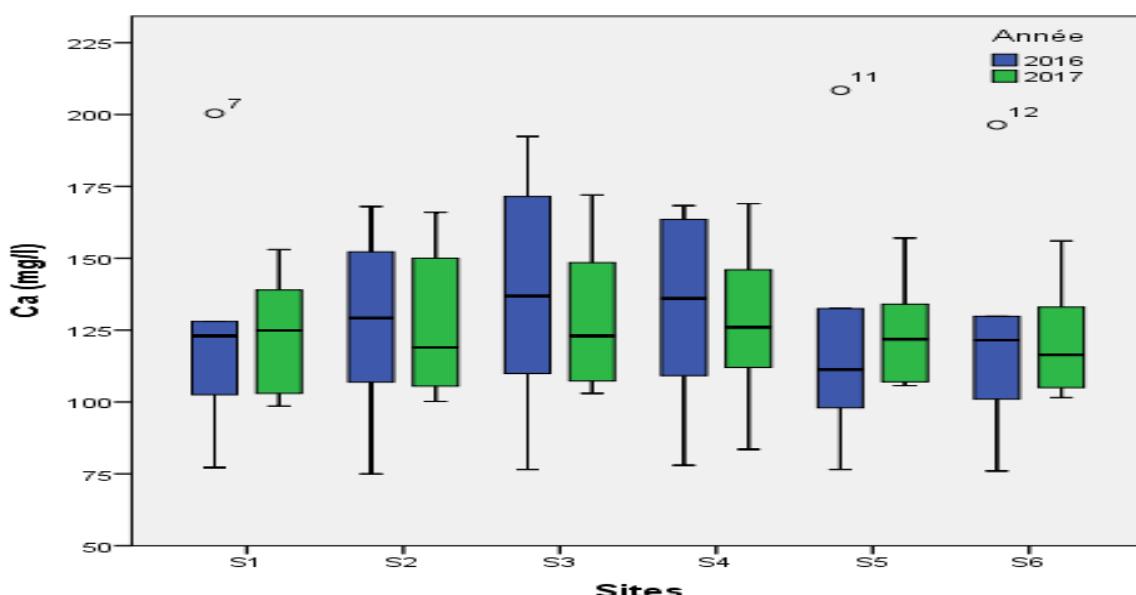
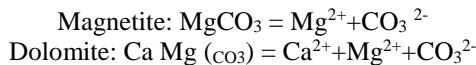


Figure 12: Amplitudes of temporal variability of calcium contents for the six study stations

In all of the societies studied, calcium ion levels follow very similarly to potassium and sodium (Figure 11). The minimum values do not show significant variations between all the stations except the S4 station during the year 2017 (Figure 12), on the other hand remarkable fluctuations between these values at the annual level.

3.6. Le Magnésium Mg²⁺ Les ions (Mg²⁺) proviennent, comme les ions calcium, de la dissolution des formations carbonatées riches en magnésium (dolomite).



The magnesium concentrations are between 72.8 and 682.3 mg/l, with an average of the order of (342.5 ± 180) mg/l. The average levels of Mg²⁺ are very high in the majority of waters studied (Figure 13). These high levels are related to the dolomitic nature of the substrate traversed by water.

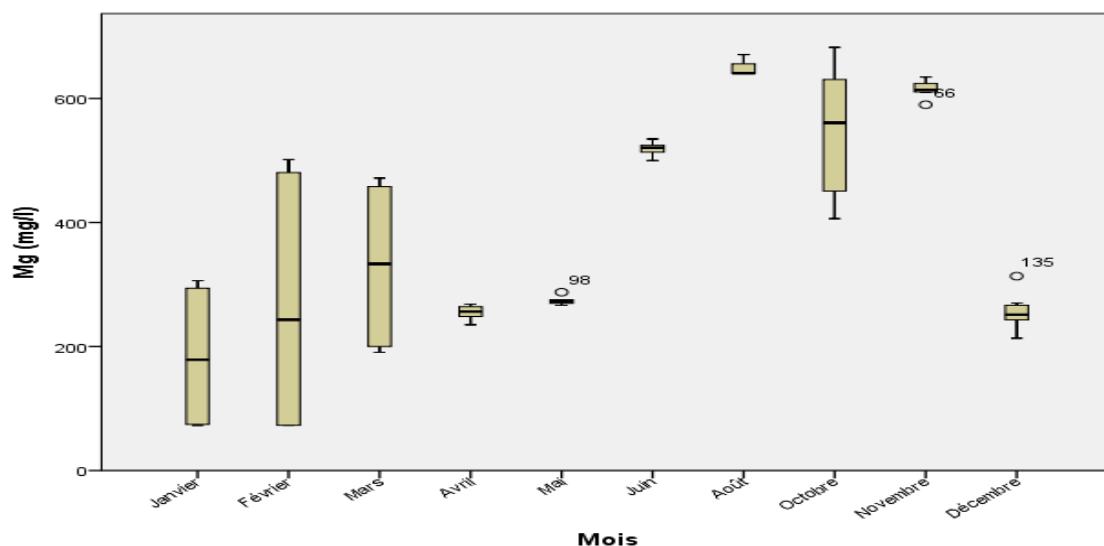


Figure 13: Box-mustache graphical representation of magnesium data from Lake water during the study period

The temporal evolution of the magnesium contents shows that the values recorded during the low water period are higher than those of the water rises, this shows the importance of the dilution with respect to the concentration for the acquisition of this element.

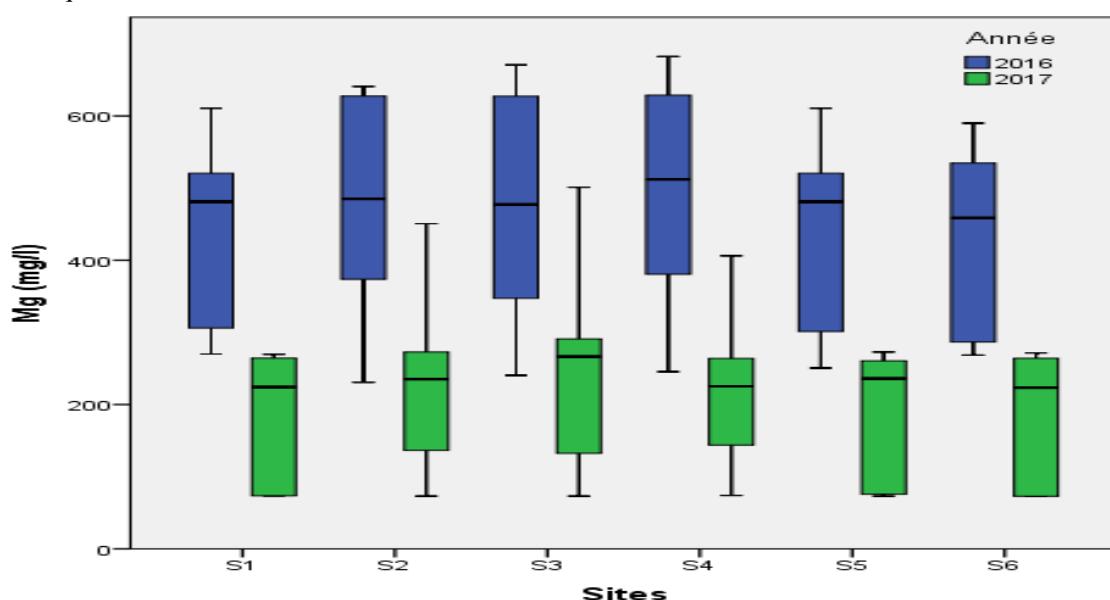


Figure 14: Amplitudes of temporal variability of magnesium contents for the six study stations

Lake waters analyzed during the year (2016) have also been characterized by high levels of magnesium ions, in comparison with those of the year 2017. In contrast to what is found in groundwater[8]–[10], the evolution of magnesium in Lake water is very different compared to that of (Ca^{2+}), and contributes more than calcium to the total hardness of the water. For magnésium, the maximum acceptable level is of the order of 150 mg/l fixed by the WHO, the comparison of the results obtained with this norm of potability shows that the majority of the stations of the sector studied do not answer this norm.

III. CONCLUSIONS

The monitoring of the quality of the collected water made it possible to observe that the spatiotemporal evolution of the physicochemical parameters of the waters of the Lake varies from one station to another, these fluctuations reflect well the real state and the nature of the waters studied. The pH values in the study area range from a low of 7.38 to a high of 8.98. The mean is (8.41 ± 0.41) which is above the median (8.60). These values are therefore not different and reflect waters close to neutrality but slightly alkaline.

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